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CORRELATION AND PATH-COEFFICIENT ANALYSIS FOR GRAIN YIELD AND AGRONOMIC TRAITS OF MAIZE (*ZEA MAYS* L.)

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ABSTRACT
Studies were conducted to estimate the direct and indirect effects of four agronomic traits on maize (*Zea mays* L.) grain yield by the application of simple coefficient correlation and path coefficient analysis in two experimental fields (Kafanchan and Kadawa). Generally, correlation coefficients among the yield component characters were similar in both locations; however path coefficients showed variation in Kafanchan and Kadawa. In the two research sites, plant height, cob length, cob diameter and 1000-grain weight had high positive correlation with maize grain yield and with each other. The path coefficient analysis revealed that plant height made the highest direct contribution (0.653 in Kadawa) to grain yield followed by 1000-grain weight with a direct contribution of 0.4290 in Kafanchan. The path analysis further disclosed these characters to be the most important components of grain yield. Both correlation and path coefficient analyses have established cob diameter as a less reliable agronomic trait than the other three variables included in the maize yield component analysis.

Keywords: Agronomic traits, Correlation coefficients, Path coefficients, Grain yield, Maize

INTRODUCTION
Maize (*Zea mays* L.) is globally important as a favored staple food for many people in Sub-Saharan Africa, Latin America and Asia (Selvaraj & Nagarajan, 2011). It is the third most important cereal crop after wheat and rice as it provides raw materials for agriculture based industries in most growing regions of the word (Anees, *et al.,* 2016). The crop is a reliable source of nourishment for humans, poultry, animals and livestock and its demand is increasing due to its versatile uses (extraction of starch, ethanol etc). The increase in demand of maize could partially be addressed either by bringing more area under maize cultivation or by increasing the productivity of the crop through the development and adoption of high yielding hybrids (Jambagi & Wali, 2016).
Maize grain yield is a complex quantitative trait that depends on a number of interacting factors: environmental conditions and various growth and physiological processes throughout the crops life cycle. Interrelationships exist between yield and its contributing components. An insight into such interrelationships can significantly improve the efficiency of breeding program (Pavlov, *et al.,* 2015) by providing appropriate selection indices. Direct selection for yield is often misleading as it is highly influenced by unpredictable environmental components (Talebi *et al.,* 2007). In this regard, correlation coefficient analysis is useful in providing knowledge for the selection of several traits simultaneously influencing yield (Menkir, 2008).

The correlation studies simply measure the associations between yield and other traits. Correlation between various characters is of great value as it indicates the degree to which various characters of a plant are associated with the economic productivity (Ahsan *et al.,* 2008). The association between two characters can be directly observed as phenotypic correlation, while genotypic correlation expresses the extent to which two traits are genetically associated (Pavlov, *et al.,* 2015). Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding program (Muhammad & Muhammad, 2001).

Path coefficient analysis has been widely used in crop breeding to determine the nature of relationships between grain yield (response variable) and its contributing components (predictor variables), and to identify those components with significant effect on yield for potential use as selection criteria (Mohammadi *et al.,* 2003). The major advantage of path analysis is that it permits the partitioning of the correlation coefficient into its components. One component being the path coefficient that measure the direct effect of a predictor variable upon its response variable; the second component being the indirect effect (s) of a predictor variable on the response variable through another predictor variable (Dewey & Lu, 1959).

Knowledge of correlation between yield and its contributing characters is a basic and fore most endeavor to find out guidelines for plant selection. Partitioning of total correlation into direct and indirect effects by path coefficient analysis helps to make the selection more effective (Priya & Joel, 2009). In view of the above, studies were conducted to estimate direct and indirect effects of four agronomic traits on maize grain yield by the application of the simple coefficient correlation and path coefficient analysis.

MATERIALS AND METHODS
The data used for the study were generated from two field experiments conducted under irrigation during 2019/2020 dry season at the Teaching and Research Farm of the Department of Crop Science, Kaduna State University, Kafanchan Campus and Kadawa Irrigation Research Station of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria, Nigeria. The investigation was carried out to evaluate the growth and yield response of irrigated maize under varying levels of inorganic fertilizer and poultry manure. The field plot design in the two locations was a randomized complete block with three replications. Plots were 3 m x 6 m (18 m^2) with six rows of maize plants spaced 0.75 m apart.

All the recommended package of practices was followed for raising a good healthy maize crop. Five plants were selected randomly in each entry for recording the observations on plant height, cob height, cob length, cob girth, no. of kernel rows per cob, no. of kernels per row, 1000-grain weight, and grain yield per plant. In addition, data relating to days to 50% tasseling and silking was also recorded on whole plot basis. The observations on grain yield per hectare, fodder yield per hectare. Shelling percentage, and harvest index were computed as per standard procedures.

Simple correlation coefficients among agronomic traits were used for the formation of the symmetric correlation matrix (R_{ij}) of independent variables (4x4). Path coefficient analysis as described by Ahmed (1997) was used to partition the correlation coefficients between maize grain yield and other characters into direct and indirect effect. Path analysis was applied to the data generated from Kafanchan and Kadawa and only characters showing significant positive correlation with grain yield were included in the path coefficient analysis. Statistical processing was done by MS Excel 2007 and MSTAT-C (1989).

RESULTS

Correlations among the five agronomic characters obtained from the field experiments in Kafanchan and Kadawa are shown in Table 1 and 2 respectively. In the two locations, a positive and highly significant correlation was found between maize grain yield and other agronomic traits. The correlation coefficients of plant height, cob length and 1000-grain weight with grain yield were about equal in magnitude in Kafanchan (0.770**, 0.790** and 0.784** respectively). However in Kadawa, the correlation between plant height and grain yield was the highest (0.907**) followed by the association of cob length and 1000-grain weight with grain yield having r values of 0.727** and 0.758** respectively. Cob diameter had the lowest correlation with grain yield in both Kafanchan and Kadawa. The results also show that the correlation between each agronomic trait was positive and highly significant in the two locations. The correlation existing for cob diameter and grain yield was lower than that between grain yield and any other agronomic character in Kafanchan and Kadawa being 0.400** and 0.442** respectively.

Table 1: Matrix of correlation coefficients of grain yield and agronomic traits in maize at Kafanchan location

Agronomic traits	Plant height	Cob length	Cob diameter	1000-grain weight	Grain yield
Plant height	1.000**				
Cob length	0.744**	1.000**			
Cob diameter	0.560**	0.602**	1.000**		
1000-grain weight	0.680**	0.624**	0.400**	1.000**	
Grain yield	0.770**	0.790**	0.634**	0.784**	1.000**

** indicates significant correlation between two variables at 1% level of significance (df = n-2)

Table 2: Matrix of correlation coefficients of grain yield and agronomic traits in maize at Kadawa location

Agronomic traits	Plant height	Cob length	Cob diameter	1000-grain weight	Grain yield
Plant height	1.000**				
Cob length	0.718**	1.000**			
Cob diameter	0.703**	0.664**	1.000**		
1000-grain weight	0.782**	0.606**	0.442**	1.000**	
Grain yield	0.907**	0.727**	0.687**	0.758**	1.000**

** indicates significant correlation between two variables at 1% level of significance (df = n-2)

Path Analysis

Path coefficient analysis was used to determine the direct and indirect contributions to grain yield of plant height, cob length, cob diameter and 1000-grain weight in Kafanchan and Kadawa. From these relations (Table 3) it is clear that plant height had the highest direct contribution to grain yield (0.6536) in Kadawa. This was followed by number of 1000-grain weight, with direct contribution of 0.4129 in Kafanchan. The magnitude of the direct contributions of cob diameter and cob length in the two locations was very small.

The data also disclose that cob diameter, cob length and 1000-grain weight made their highest indirect contribution to grain yield through plant height in Kadawa compared to any other paired contribution in this study. The indirect contribution of these variables via plant height was mainly responsible for the total contribution of the characters to grain yield in the experimental site. Furthermore, the indirect contribution of plant height through 1000-grain weight (0.3179) in Kafanchan was the fourth largest indirect contribution to maize grain yield. It is noteworthy that the indirect contribution of any agronomic trait through its association with cob diameter was very small in the two experimental fields.

Table 3: Path-coefficient analysis showing the direct and indirect effects of agronomic traits on yield in maize at Kafanchan and Kadawa locations

PATH – WAY		PATH – COEFFICIENT	
Agronomic traits	Code	Locations	
		Kafanchan	Kadawa
Plant height and Grain yield			
Direct contribution	P_1	0.1572	0.6536
Indirect via cob diameter	$r_{12} P_2$	0.1183	0.0640
Indirect via cob length	$r_{13} P_3$	0.2172	0.0817
Indirect via 1000-grain weight	$r_{14} P_4$	0.3179	0.1077
Total contribution	r_{18}	0.7700	0.9070
Cob diameter and Grain yield			
Direct contribution	P_2	0.2051	0.0911
Indirect via plant height	$r_{12} P_1$	0.0881	0.4595
Indirect via cob length	$r_{23} P_3$	0.1758	0.0756
Indirect via 1000-grai weight	$r_{24} P_4$	0.1652	0.0609
Total contribution	r_{28}	0.6340	0.6870
Cob length and Grain yield			
Direct contribution	P_3	0.2919	0.1138
Indirect via Plant height	$r_{13} P_1$	0.1168	0.4693
Indirect via cob diameter	$r_{23} P_2$	0.1234	0.0605
Indirect via 1000-grain weight	$r_{34} P_4$	0.2577	0.0834
Total contribution	r_{38}	0.7900	0.7270
1000-grain weight and grain yield			
Direct contribution	P_4	0.4129	0.1377
Indirect via plant height	$r_{14} P_1$	0.1069	0.5111
Indirect via cob diameter	$r_{24} P_2$	0.0820	0.0403
Indirect via cob length	$r_{34} P_3$	0.1822	0.0690
Total contribution	r_{48}	0.7840	0.7580

DISCUSSION

The correlation between maize grain yield and all the agronomic traits was positive and highly significant. This suggests that selection for these traits would be effective in a maize yield improvement. Characters like number of grains per row, 1000-grain weight, cob diameter and plant height were found to be useful in improving maize grain yield in hybrids (Nemati, *et al.,* 2009). Plant height had about the highest positive coefficient in both Kafanchan and Kadawa. This may imply that plant height was more important than any other agronomic trait in determining maize grain yield. 1000-grain weight ranked second, while cob diameter was the least important trait of maize grain yield ranking fourth in both Kafanchan and Kadawa. Bello *et al.* (2010) has reported that grain yield had a significant and positive correlation with 100-grain weight, shelling percentage, cob length, cob girth, ear height and plant height. This indicates that the traits play a great role as important contributing characters for higher grain yield.

In general, the order of importance for the agronomic traits in contributing to maize grain yield was plant height, 1000-grain weight, cob length and cob diameter. The high correlation coefficient between plant height, cob length and 1000-grain weight may suggest that maize plant with long stem will consequently have long cobs and a high weight of 1000-grains. A positively and significantly associated between grain yield and 100-seed weight, ear girth, ear length and plant height have been reported previously (Selvaraj & Nagarajan, 2011; Jambagi & Wali, 2016). The relatively low significant positive correlation obtained between 1000-grains and cob diameter in the two experimental fields indicates that selection for one character may not be strongly connected to the other in determining final maize grain yield. From a practical point of view, increasing the weight of 1000-grain or cob diameter would naturally be expected to increase cane yield.

The relative influence of the agronomic traits on maize grain yield in both Kafanchan and Kadawa is shown by the direct contribution component of the partitioned total correlations. The results of the path analysis showed that the direct effect of plant height on grain yield was the highest. In line with our result, Jambagi & Wali (2016) had observed the positive direct effect of plant height, cob length, cob girth and 100-grain weight on grain yield and suggested the direct selection of the characters for increasing maize grain yield. Similarly, the indirect effect of other agronomic characters through their association with plant height was high. This finding emphasizes the role of plant height in determining maize grain yield, as was indicated by the correlation studies.

1000-grain weight also gave high correlation coefficient being 0.7840 and 0.7580 in Kafanchan and Kadawa respectively. However, the high correlation was largely due to its direct effect on maize grain yield in Kafanchan and indirect effect through stalk length in Kadawa. This qualifies 1000-grain weight as second in importance for determining grain yield, as demonstrated by the correlation analysis. Mohammadi *et al.,* (2003) had reported that 100-grain weight and total number of kernels per ear had exerted the highest direct effects on total grain weight ($p = 0.74$ and $p = 0.78$, respectively). Previously, Devi, *et al.* (2001) observed that ear length, number of seeds rows ear-1, number of seeds row-1 and 100-seed weight had a positive influence on yield directly and also indirectly through other components.

Furthermore, 1000-grain weight was about twice as important as cob diameter and cob length and approximately three times as important as plant height in determining grain yield in Kafanchan. Never the less, in Kadawa, the relative importance of plant height was greater than other agronomic traits in determining grain yield. Thus, it appears that, variation in geographical location can alter the relative importance of characters in determining grain yield. Pavlov (2015) had cited Bocanski, *et al.* (2009) who referred to grain yield as a complex quantitative trait that depends on a number of factors and under great influence of environmental conditions with a complex mode of inheritance and low heritability.

Conclusion

The agronomic trait analysis conducted on irrigated maize through path analysis have shown that 1000-grain weight and plant height are the most important characters directly contributing to grain yield. However, correlation analysis have place plant height, cob length and 1000-grain weight (with about equal coefficient value in the two experimental fields) on the same pedestal in terms of contribution to grain yield. The analysis carried out indicated that for breeding purpose, improvement in maize crop yield would be best accomplished by emphasizing long maize plants and 1000-grain weight compared to other agronomic traits. The outcome of this study has reiterated the fact that in some circumstance, differences in geographical location can alter the relative value of agronomic traits in determining maize grain yield.

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